Dr. Weaver has had a lifelong interest in probability and statistics. He was given the first Archives of Science Award for his contribution to public appreciation of science.

In the U.S., too, government representatives want explanations. For example, Craig Hosmer, a House Member of the House and Senate Committee on Atomic Energy, in discussing the funding of science at a technological conference on March 5, 1968, said: "The scientific community should take greater pains to make clear that its efforts contribute directly and indirectly to the public good."

Thus, these and other important men ask scientists to tell the public about their subject and to explain what contribution science makes to society. Their request is easier made than satisfied. This collection of essays on applications of statistics represents one kind of step toward meeting it.

To find the origins of this work, we might turn back to the great change and advance in mathematics education initiated in 1954 when the Commission on Mathematics of the College Entrance Examination Board brought together, for a sustained study of the curriculum, teachers and administrators of mathematics from several sources: secondary schools, teachers' colleges, and colleges and universities. Prior to that gathering, the several groups of teachers had seldom worked together on the problems of the curriculum. That meeting of minds has developed and continued in many directions; one of its long-run consequences was the establishment of the Joint Committee of the American Statistical Association (ASA) and the National Council of Teachers of Mathematics (NCTM) on the Curriculum in Statistics and Probability. By late 1967, such cooperation between school and college teachers was widespread, and it was easy for Donóvan Johnson, then President of NCTM, and me, then President of ASA, to set up the Joint Committee to review matters in the teaching of statistics and probability.

Early in its work the Joint Committee decided that it wanted to encourage the teaching of statistics in schools, for statistics is a part of the mathematical sciences that deals with many practical, as well as esoteric, subjects and is especially organized to treat the uncertainties and complexities of life and society. To explain why more statistics needs to be taught, we need to make clearer to the public what sorts of contributions statisticians make to society. In the field of statistics, we are, indeed, responding to the sort of requests quoted above.

When describing work in the mathematical sciences, one must make a major decision as to what level of mathematics to ask of the reader. Although the Joint Committee serves professional organizations whose subject matter is strongly mathematical, we decided to explain statistical ideas and contributions without dwelling on their mathematical aspects. This was a bold stroke, and our authors were surprised that we largely held firm.

The Joint Committee has been extremely fortunate to find so many distinguished scholars willing to participate in this educational project. The authors' reward is almost entirely in their contribution to the appreciation of statistics. We have been fortunate, too, to have Judith Tanur as editor of the collection and hard-working committee members as her staff.

STATISTICS:
A GUIDE TO THE UNKNOWN

HOLDEN-DAY SERIES
IN PROBABILITY AND STATISTICS

E. L. Lehmann, Editor

*To be published

STATISTICS:
A GUIDE TO THE UNKNOWN
Second Edition

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PREFACE TO SECOND EDITION

SINCE THE publication of STATISTICS: A Guide to the Unknown (SAGTU) five years ago, three related publications have appeared, each of them consisting of a subset of about a dozen of the SAGTU essays dealing with (i) business and economics; (ii) the biological and health sciences; (iii) political and social issues. Two of these volumes also contained one new essay each (by Gilbert, McPeek and Mosteller on innovations in surgery and anesthetics for (ii) and by Gilbert, Light and Mosteller on political and social innovations for (iii).) In addition, each of the essays in these Mini-SAGTUS was supplemented by a set of problems. The original editors reviewed and approved the new material.

The present, second edition of SAGTU, supervised by Erich Lehmann, differs from the first principally by some minor editorial changes for updating, the addition of the two new essays and the problems mentioned above, and of problems also for the essays not contained in the Mini-SAGTUS. It is the hope of the editors that these problems will help focus the reading of the essays and will make them more useful in the classroom. This supplementary study material is the valuable contribution of David Lane, Donna and Leland Neuberg, Rick Persons, Haiganoush Preisler and Esther Sid.

Judith M. Tanur
Frederick Mosteller
Erich L. Lehmann

PREFACE TO FIRST EDITION

To PREPARE a volume describing important applications of statistics and probability in many fields of endeavor—this was the project that the ASA-NCTM Committee invited me to help with in early 1969. It was the Committee's view that more statistics and its background and probability would be desirable in the school curriculum; thus it would be desirable to show how broadly these tools are applied. The Committee planned this book primarily for readers without special knowledge of statistics, probability, or mathematics. This audience included especially parents of school children, school superintendents, principals, and board members, but also teachers of mathematics and their supervisors, and finally, young people themselves. *Statistics: A Guide to the Unknown* is the result. During the time of the book's preparation several of us who were working on it and teaching simultaneously found much of the material very useful—even inspirational—to undergraduate and graduate students. It would seem that, quite unexpectedly, the book has an additional possible function as an auxiliary textbook.

Instead of teaching technical methods, the essays illustrate past accomplishments and current uses of statistics and probability. In choosing the actual essays to include, the Committee and I aimed at illustrating a wide variety of fields of application, but we did not attempt the impossible task of covering all possible uses. Even in the fields included, attempts at complete coverage have been deliberately avoided. We have discouraged authors from writing essays that could be entitled "All Uses of Statistics in ..." Rather, we asked authors to stress one or a very few important problems within their field of application and to explain how statistics and probability help to

solve them and why the solutions are useful to the nation, to science, or to the people who originally posed the problem. In the past, for those who were unable to cope with very technical material, such essays have been hard to find.

To us, this spread of applications gives a renewed appreciation of the unity in diversity that is statistics. On the one hand, we found the same, or similar, statistical techniques being applied in unrelated fields. Authors described the use of correlational analysis in contexts as diverse as a study of the sun, a test of the relative importance of economic variables, an exploration of the components of leadership in the military, and an examination of the effect of registration regulations on voting turnout. Other authors dealt with applications of sampling theory in such disparate fields as accounting, improving the U.S. Census, and opinion polling. And essay after essay discusses experimental design and the necessity, as well as the difficulty, of making inferences from less-than-perfect data. Certainly this is unity in diversity that will help to demonstrate to the general public the wide usefulness of statistical tools.

On the other hand, we found essays grouping themselves into unities of subject matter with differing statistical techniques. For example, two otherwise unlike essays deal with the evaluation of the effectiveness of innovations in traffic control procedures in reducing accidents. At least four essays describe very different methods of studying diseases, their causes and cures—the testing of the value of the Salk vaccine, a mathematical model for disease epidemics, a history of the study of the association between smoking and ill health, and an explanation of the uses of twins in research on illness.

We have tried to emphasize these unities and at the same time avoid unnecessary repetition by a system of cross-referencing. Thus, whenever another essay contains material that will assist the reader to understand the present essay or give him further insight into a particular problem, he is directed to it.

Once our 44 essays had been assembled and edited, we had to decide on their order. Several orderings seemed feasible: we might group the essays by type of statistical tools employed, thus stressing the unity of statistical tools and ignoring the diversity of usual disciplinary lines; we might group essays by the method used for collecting data—sample survey, experiment, Census material, and so on; or we might group them by subject matter of the application.

What we have chosen is the last of these modes of organization. We have classified into four broad areas by field of application, with subdivisions within each. Each subdivision is small enough, cohesive enough, and digestible enough to be read as a single unit and to give an overview of applications within a narrow field. But we were unwilling to forgo the advantages of the other possible methods of classification; following the main table of contents, therefore, are two alternate tables of contents, the first organized by method of collecting the data, the second by statistical tools. In the latter listing, an essay has been listed under a heading whenever the author used that tool, or whenever we felt the reader might learn something about the technique by looking at the essay, or both.

These efforts at classifying emphasized, for us, an aspect of the book we had not deliberately planned or even been aware of earlier. It turned out that we had a large

group of essays dealing with public policy, many of them classified under our main grouping entitled "Man and His Social World." We also found that several of this group deal with the evaluation of reforms or changes in policy. On the one hand, we found ourselves with descriptions of two large-scale field experiments: the speed-limit experiments in Scandinavia and the Salk vaccine trials. It seems that in the U.S. until recently, we have done few of these controlled experiments, and it appears to the Committee that one of the jobs that statisticians have been somewhat neglecting is explaining to the public the possibilities and values of experimentation. The public needs such explanations to have a sound basis for deciding whether it wants such experimentation to be carried out. On the other hand, several deal with nonexperimental (or quasi-experimental) evaluations of reforms: Did the Connecticut crackdown on speeding decrease traffic accidents? Did the assignment of more patrolmen to a New York City precinct decrease crime? Is a particular anesthetic dangerous?

We hope that both types of essays will contribute to a greater appreciation of how hard it is to find out whether a program is accomplishing its purposes. Such understanding would give people a little more sympathy for government officials who are trying to do difficult jobs under severe handicaps. It may also, as pointed out above, encourage them to press government to do better-controlled field studies both in advance of and while instituting social reforms.

There is an old saw that a camel is a horse put together by a committee. Our authors supplied exceedingly well-formed and attractive anatomical parts, but to the extent that this book gaits well, credit is due primarily to a most talented and dedicated Committee. In general, the approach to unanimity in the Committee's critical reviews of and suggestions about essays was phenomenal. And, though they may have occasionally been divided about the strong and weak points of a particular essay, they were constantly united in their purpose of producing a useful book, and in their ability to find something more than 24 hours a day to work on it. This dedication, together with my own compulsiveness, has undoubtedly created difficulties for our authors. Nevertheless, our authors persevered and deserve enormous thanks from me, from the Committee, and from the statistical profession at large.

Our thanks go also to the Sloan Foundation whose grant made it possible to put this book together.

There are others to thank as well: for the hard work and advice of George E. P. Box, Leo Breiman, Churchill Eisenhart, Thomas Henson, J. W. Tukey, and the late W. J. Youden; to the office of the American Statistical Association (and, in particular, to Edgar Bisgyer and John Lehman) for invaluable help in all the administrative work necessary to get out a book such as this; and similar thanks to the administration of the National Council of Teachers of Mathematics; to Edward Millman for careful and imaginative editorial assistance; and to other people at Holden-Day, especially Frederick H. Murphy, Walter Sears, and Erich Lehmann, our Series Editor; to Mrs. Holly Grano for acting as a long-distance and long-haul secretary; and to the many friends and colleagues both of the Editor and of the Committee members who so often acted as unsung, but indispensable advisors.

Judith M. Tanur
Great Neck, New York
February 14, 1972

FOREWORD

THE RIGHT Honorable Harold Wilson, Prime Minister of Great Britain, in opening the 37th Session of the International Statistical Institute in London, September 4, 1969, said:

> The list of papers for the Session reflects the ever widening range of application of statistical methods. When I joined the Royal Statistical Society the papers read were still mainly on economic and social statistics. Nowadays the papers read before a society like those for your session of the Institute cover many more topics relating to many disciplines. It means, I am afraid, that as statisticians today you help so many people in so many diverse subject fields that none of your clients can see the overall contribution which you as statisticians make together as a whole. As a result your value is not perhaps sufficiently recognized by any one group of the people with whom you deal nor are your great services fully realized by the general public.

Himself a statistician, the Prime Minister understood well these contributions of statistics. He might be interpreted as calling for statisticians to explain what they do.

Warren Weaver, a great expositor of science, discussed why science is not more widely appreciated and issued a similar call in "The Imperfections of Science" (*American Scientist*, 49:113, March 1961):

> What we must do—scientists and non-scientists alike—is close the gap. We must bring science back into life as a human enterprise, an enterprise that has at its core the uncertainty, the flexibility, the subjectivity, the sweet unreasonableness, the dependence upon creativity and faith which permit it, when properly understood, to take its place as a friendly and understanding companion to all the rest of life.